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AUTHOR Chan, Gordon L.
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ABSTRACT

Described is an auto-tutorial slide program for zoology students. A self-paced system was devised for observing the subject matter covered in the twelve study units of a zoology course. The post-testing evaluation revealed that students with lower grade point averages achieved scores comparable with students of higher grade point averages. (Author/DS)

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AN EVALUATION OF A BIOLOGICAL SLIDE-TUTORIAL PROGRAM

OCTOBER, 1977

by

Gordon L. Chan
College of Marin
Kentfield, CA 94904

SE 031 771

Abstract

A NSF-CAUSE grant was provided to the College of Marin for the development of an audio-tutorial slide program for zoology students in the spring semester of 1977. A self-paced system was devised for observing the subject matter covered in the twelve study units of a zoology course. The post-testing evaluation in these units revealed that students with lower grade point averages achieved scores in a comparable range with students of higher grade point averages.

Acknowledgements

The project at the College of Marin was sponsored by the National Science Foundation, Comprehensive Assistance to Undergraduate Science Education (CAUSE), Project No. SER 76-15926, for 1976-77. The technical program was administered by Ann Cole. Maxine Chan prepared the data for evaluation and typed this report. My profound gratitude is extended to these organizations and individuals.

MAY 9 1980

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AN EVALUATION OF A

BIOLOGICAL SLIDE-TUTORIAL PROGRAM

AT THE COLLEGE OF MARIN

I. INTRODUCTION

The College of Marin is a two-year community college located ten miles north of San Francisco and serving a varied population with a credit enrollment of about 6,000 students. Throughout the school year, some 2,400 students enroll in twenty-seven major and non-major biology courses. The primary instructional methods include the use of the traditional lectures, laboratory work, and field observations. The following statements present some of the problems generally associated with biology instruction:

1. Students cannot progress or review materials at their own individual rate. Laboratory and lecture materials are usually given at set time schedules.
2. Students who are absent have a disadvantage in making up the missed opportunities.
3. Field trips are usually restricted to local habitats; consequently, other world ecosystems cannot be visualized except through the media such as movies. Also, the physically handicapped students are almost totally excluded from participating in extensive field trips.
4. The study of laboratory organisms in zoology is basically restricted to formalin-bleached specimens, and these animals are far removed from their natural habitat.

The formation of a slide-tutorial program at the Biology Department of the College of Marin resulted from the blending of two distinct entities: an extensive private slide collection and the National Science Foundation's

Comprehensive Assistance to Undergraduate Science Education (CAUSE) funding for incorporating these slides into a permanent instructional process. As an instructor of biology for twenty-two years, I had accumulated over 20,000 35mm slides from extensive marine expeditions, recording mostly underwater scenes of marine organisms in their natural habitats.

The primary objective of NSF/CAUSE is:

> "To strengthen the resources and quality for undergraduate science education components of the Nations's two-year and four-year colleges and universities."(1)

To implement this objective, it was the original intent of this project to utilize these slides to enhance the total Biology Department's instruction program, encompassing nine instructors and twenty-seven courses. However, the fusion of a slide-tutorial program into a large diversity of courses presented monumental obstacles which could not be solved within the one-year grant program. Therefore, the necessary modification of the CAUSE project resulted in the development of a slide-tutorial program for a single zoology course, with an evaluation of the project for this course in great detail.

The problem was clear—would the incorporation of these slides into the subject matter of zoology accelerate the learning process for these biology students? Zoology is traditionally taught with the review of the major phyla, with students dissecting bleached-preserved animals, enhanced by some live organisms and field trips. There have been many reports pointing out the advantages and gains of audio-tutorial programs (2). Thus, the expectation for the success of this project was high.

II. METHODS and PROCEDURES

The 1977 spring semester course selected for the CAUSE project was Biology 2, Zoology, a major's course taken by students who plan to transfer to a four-year college or university.

A. Background of Students

1. At the beginning of the semester in January, 1977, a pre-course questionnaire (Appendix 1) was given to the students to obtain information on science education, academic achievement, and science experience. School courses completed were weighted from 0 to 3 points each, according to their relative contribution toward a basic science background. Each student's total points for these science courses were multiplied by his or her grade point average to arrive at a code number.
2. A pre-test was given before the introduction of the study units in lecture to determine the student's prior knowledge of the subject matter. The test consisted of ten multiple-choice questions; the score did not count toward the course grade.

B. Caramate Units

The slide-audio-tutorial system was basically established to supplement the lectures, laboratory work, and field observations. Thirteen caramate units were developed (Appendix 2), one for each of the twelve study units and the final one for a complete course review. Each study unit of slides was accompanied by a cassette tape and was operated through a caramate audio-screen apparatus housed in the college's Media Center and administered by its personnel. Each caramate unit was made available to students after the introduction in lecture of that study unit and remained available for the rest of the semester, to be viewed at the student's convenience and need.

C. Progress of Students (Post-tests)

For the course grade, the usual credits for lab reports, field trip write-ups, midterm and final examinations were required. Alternate exams were available to students who chose not to accept their initial exam scores.

In addition, for each study unit, three different post-tests, similar to the 10-multiple-choice pre-test, were available for a three-week period following the introduction in lecture of that study unit. Students could take any or all of the 3 post-tests for each unit, administered at the Media Center at the student's convenience, with a required passing score of 9 or 10. Only the highest post-test score (passing or not) attained by the student for each unit counted toward the course grade. For a review before each midterm, time was made available for students to ask questions regarding any of their post-tests.

Example of Sequence for one study unit - Study Unit 2- Porifera

1. Pre-test in class.
2. Lecture on sponges by instructor
3. Laboratory observations of sponges
4. Caramate unit on sponges, available at Media Center.
   Slides reviewed:
   a. lecture material
   b. laboratory observations on cellular structure of sponges
   c. natural habitats of sponges found throughout the world
5. Post-tests (choice of 1 to 3 tests to attain passing score), available over period of three weeks following 1st lecture on sponges.

D. Evaluation Methods

1. Students' use and evaluation of the caramate slide units.
2. Comparison of pre-test and post-test scores on each study unit.
3. Comparison of 1977 Biology 2 exam scores with those of previous years.
4. Comparison of students' previous grade point averages in relation to achieved scores.
5. Statistical analyses of data for 95% confidence interval for population means. Testing for significant difference between population means ($\alpha = .05$).

III. DATA and OBSERVATIONS

The course, Biology 2-Zoology, was completed by 30 students. Of these, 26 gave sufficient information on the pre-course questionnaire to obtain a code number. A code number of 20 was considered sufficient basis for success in Biology 2 with a final grade of B, based on GPA and a combination of basic science courses, high school and/or college.

A. Background of Students

1. According to Grade Point Average and Year/s in College

There were no students with college degrees; 62% had completed at least one year of college, Figure 1 below. The grade point average (GPA) for previous high school and college biological and physical science courses were tabulated for three categories: (1) at least 3.5 GPA, (2) at least 3.0 GPA, but less than 3.5, and (3) less than 3.0 GPA.

GPA	College Year: Grad	≥1	<1	totals
≥ 3.5	0	3	5	8 (31%)
≥ 3.0	0	9	4	13 (50%)
< 3.0	0	4	1	5 (19%)
totals	0	16	10	26 students
		62%	38%	100%

Figure 1. Distribution of Class according to College Year/s Completed and Grade Point Average for High School and College Physical and Biological Science Courses.

B. Use of Caramate Slide Units

1. Time Spent Viewing Caramate Units

At the beginning of the semester, total class enrollment varied up to 46. Figure 2 covers a 15-week period and includes all viewing students. The average number of students was 21 per week, ranging from high of 36, week #1, to low of 7, week #15, just before final exam. Similar declines for weeks #6 and #11 correspond to Midterms 1 and 2 scheduled at that time.

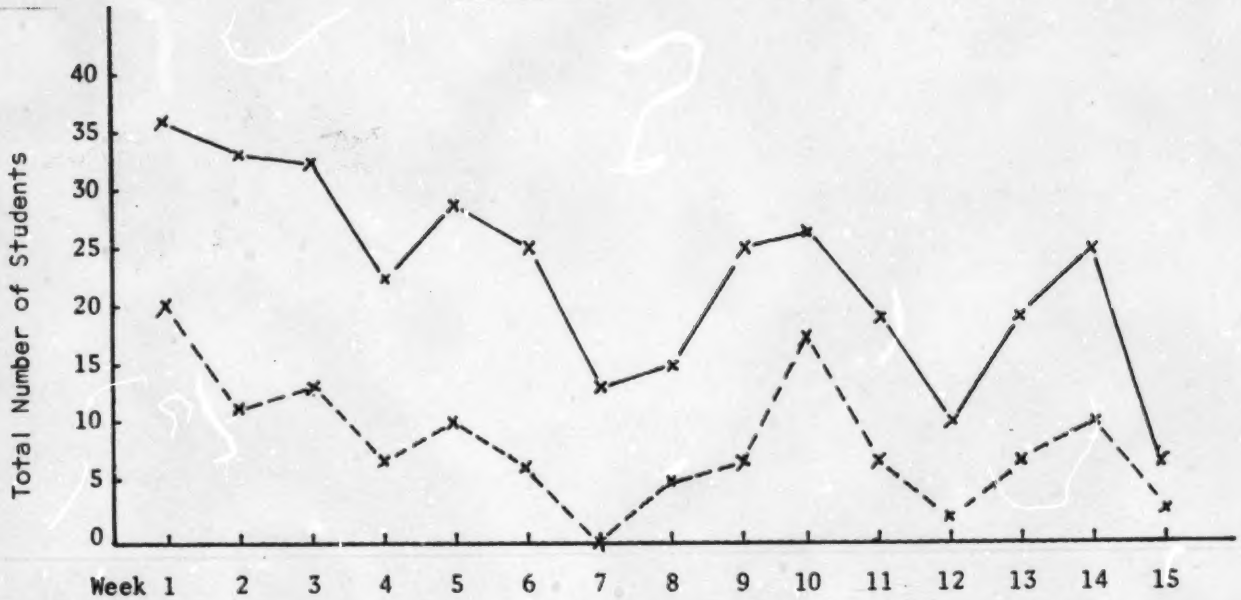


Figure 2. Total Number of Student Using the Caramate Units

x——x Total number of students for the week

x- - -x Total number of students who used caramate 2 or more times

The percentage of viewing students making 2 or more visits a week to the Media Center reached a high of 65% for week #10, with an overall average of 35% per week. Individual viewing time (one visit) ranged from 15 minutes to 4 hours. The overall average viewing time per student per week was 1.2 hours.

Figure 3 below shows the total number of hours spent by the students to view each caramate unit.

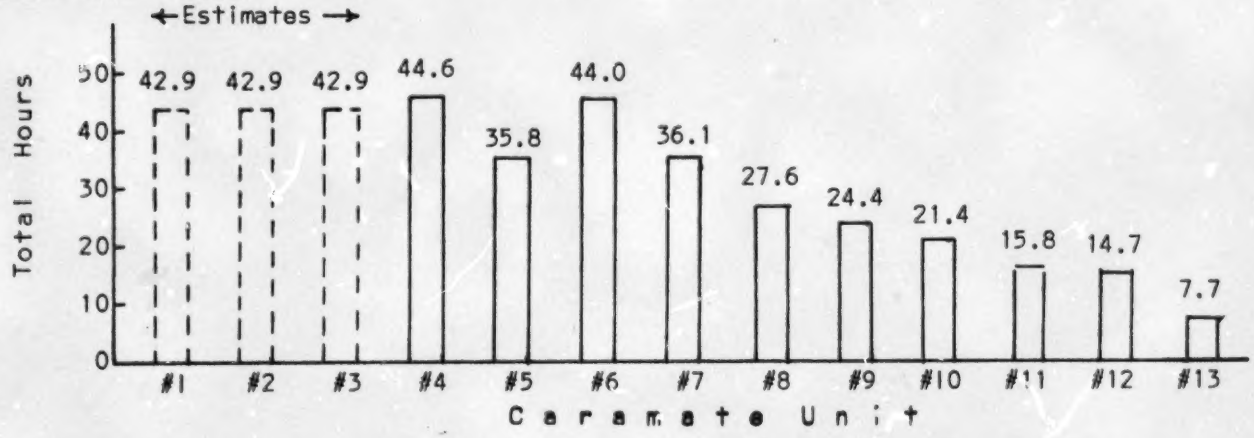


Figure 3. Total Time by Students to View Each Caramate Unit

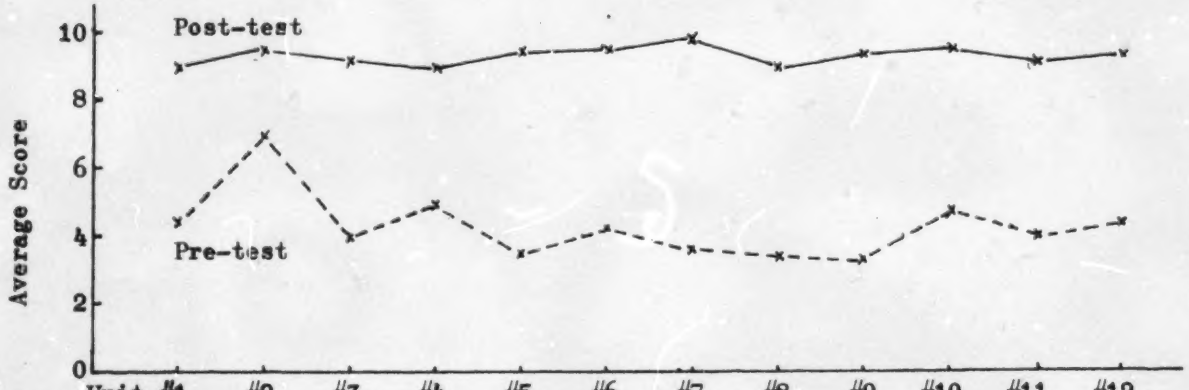
Estimates for units #1-3 were necessary because some students neglected to indicate on the record sheet which unit they were viewing. Total hours for a single caramate unit ranged from 7.7 to 44.6 hours, with a grand total of 400.8 hours for all 13 units, an average of 30.8 hours per caramate unit.

2. Evaluation of Caramate Units by Students

The Biology 2 semester evaluation by the students revealed some favorable comments about the caramate units, Appendix 3. Despite some shortcomings in the audio-tape recordings, the students were unanimous in their opinion that the slide units benefited their academic learning and would recommend its continued use in the course. Although the caramate unit viewing was compulsory for each student, the evaluation survey showed that 96% of the students responding would have viewed the units even if they were optional. In summary, I was particularly gratified over the positive feedback from the students.

C. Pre-tests and Post-tests

A comparison of the average pre-test and post-test (highest) scores for each study unit is shown in Figure 4 below. Pre-tests were usually given before the first lecture of each unit. Unit #2 pre-test was given after the lecture, thus accounting for the high 6.9 average.

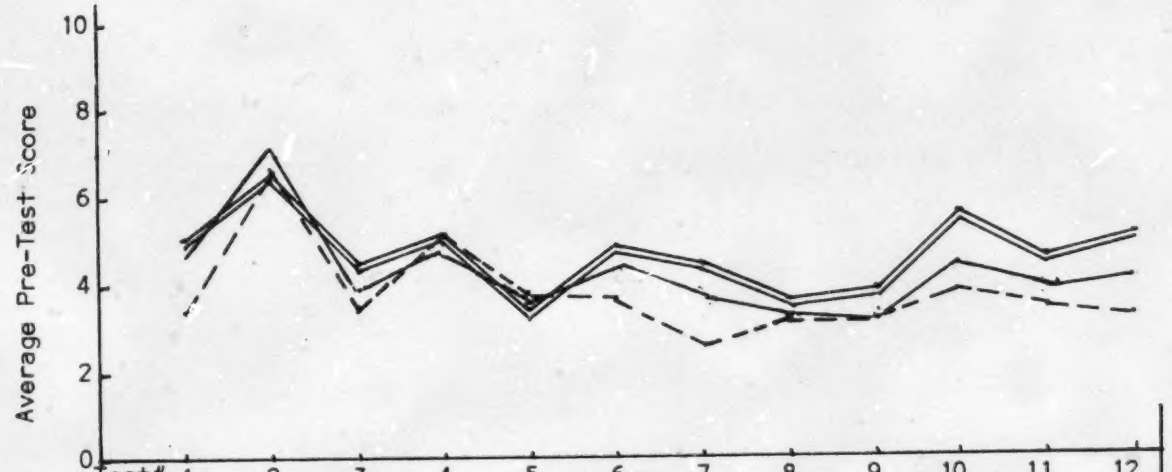


Unit	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
Post-test	8.9	9.5	9.2	9.1	9.4	9.5	9.8	9.1	9.4	9.4	9.2	9.2
Pre-test	4.5	6.9	4.0	4.9	3.5	4.3	3.7	3.4	3.4	4.6	4.0	4.3

Figure 4. Comparison of Average Pre-test and Post-test Scores for Each Study Unit

Pre-tests #6-8 and #9-12 were given as blocks of tests, unannounced, prior to units #6 and #9, respectively, to avoid the use of pre-tests by students as "practice tests". The overall pre-test average for all units 4.3; post-test was 9.3, for an average improvement of 5.0 points, Figure 4.

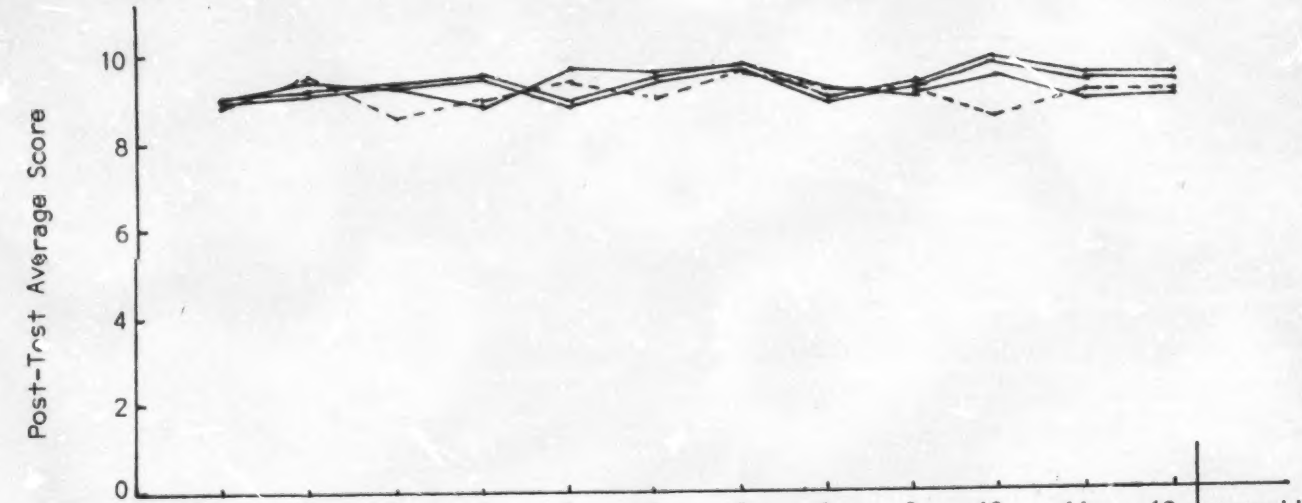
A comparison of pre-test averages, according to the three GPA groups, Figure 5, shows some close alignments of averages for all groups (units #2-5), as well as divergence among the groups (units #6-12). As might be expected, students with higher GPA's generally scored higher than lower GPA students. There was only one significant difference between population means for overall averages: an interval of difference, 0.3 to 1.5 points, between GPA $\geq$ 3.5 and GPA $<$ 3.0 groups only (sample means 4.7 vs. 3.8).



Test#	1	2	3	4	5	6	7	8	9	10	11	12	overall
GPA≥3.5(═══)	4.9	6.5	4.4	5.1	3.3	4.8	4.4	3.6	3.9	5.6	4.6	5.1	4.7
GPA≥3.0(——)	4.8	7.2	3.9	4.7	3.5	4.4	3.7	3.4	3.2	4.4	3.9	4.2	4.3
GPA <3.0(- -)	3.4	6.6	3.4	5.0	3.6	3.6	2.6	3.2	3.2	3.8	3.4	3.2	3.8

Figure 5. Comparison of Pre-Test Averages according to Grade Point Average Groups (26 students)

A comparison of post-test averages, according to GPA groups, would show, I assumed, the same pattern, with generally higher averages for the higher GPA students. However, Figure 6 indicates no such consistency of arrangement, except for units #7 and 10. There was no significant difference between any of the groups for population means for the overall post-test averages, which were almost identical: 9.4, 9.3, and 9.3.



Test#	1	2	3	4	5	6	7	8	9	10	11	12	overall
GPA≥3.5(═══)	8.9	9.3	9.4	9.6	9.0	9.5	9.8	9.0	9.4	9.9	9.6	9.6	9.4
GPA≥3.0(——)	8.9	9.5	9.3	8.9	9.7	9.6	9.8	9.2	9.1	9.5	9.0	9.1	9.3
GPA< 3.0(- -)	8.8	9.6	8.6	9.0	9.4	9.0	9.6	9.2	9.2	8.6	9.2	9.2	9.3

Figure 6. Comparison of High Post-Test Score Averages according to Grade Point Average Groups (26 students)

In summary, the data seems to indicate, at least for this project, that students with lower GPA, given the opportunity to view caramate slides at their own pace and to take tests and re-tests as needed, can achieve on a comparable post-test level with higher GPA students.

D. Midterm and Final Examination Scores, 1972-1977

Although I have been teaching the Biology 2, Zoology, course for the past twelve years at the College of Marin, it was not until 1972 that I settled on the present system of teaching the animal kingdom in a phylogenetic relationship, as the best instructional presentation of the subject. Midterm 1 and final examinations for 1972 through 1977 covered essentially the same subject matter in the same number of questions, although questions used in the exams varied from year to year.

Figure 7 shows, for Midterm 1 exams, significant difference between population means between 1972 and 1974, and between 1974 and the years 1975-77. (See Appendix 4 for statistical data.) For Final exams, there was a significant difference for population means between 1972 and 1973-77, and

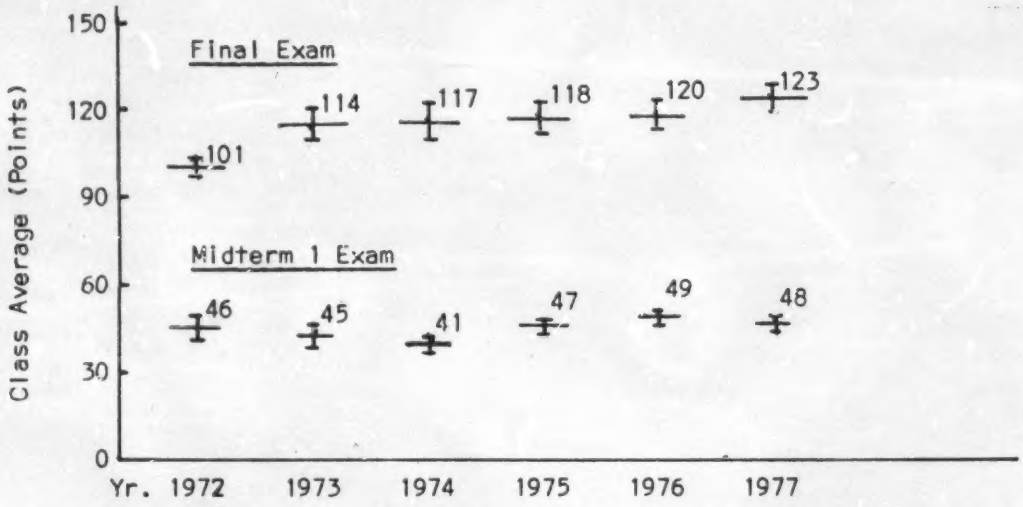


Figure 7. Comparison of Midterm I and Final Examination Averages for Biology 2 Classes, 1972-1977.

— sample mean I 95% confidence interval for population mean

between 1973 and 1977. There was no significant difference between the years 1974-77. The 1977 sample mean, however, did show a higher average than that of previous years. Testing between the three GPA groups showed no significant difference between population means for Midterm 1 and for total semester points for the course; there was significant difference in Final exam only between GPA $\geq$ 3.5 and GPA $<$ 3.0 groups (interval of 1.5 to 29.5 pts).

E. Final Course Grades, Spring 1977

GPA	A	B	C
$\geq$ 3.5	5	1	2
$\geq$ 3.0	7	6	
$<$ 3.0	2	2	1

In the highest GPA group (3.5), two students received C's; both had no previous college education and perhaps needed more college instruction orientation. In the lowest GPA group, 2 students achieved A's, and 2 achieved B's.

IV. CONCLUSION and SUMMARY

Supported by a NSF-CAUSE grant in the school year 1976-77, a caramate-slide educational program was established for zoology students at the College of Marin. I had much hope that my thousands of slides, illustrating marine organisms from all seas of the world, would enhance the interest and quality of biological instruction. The slides were to be viewed on a self-paced system; post-tests for each of the twelve study units were also given at student's individual pace over a three-week period for each unit.

The final measure of learning is not an easy task. Many educators over the past decades have struggled with the evaluation process. There remains an old educational axiom that bright students will achieve no matter what type of instruction or teaching methods are administered, and in my 25 years of teaching, I sense this to be true. But, what of the students with average abilities, with lower grade point averages? What is the final expectation for these students?

In the pre-test gauge of knowledge of subject matter, the higher GPA students scored better than lower GPA students; this was expected. There were 3 post-tests available for each study unit, which all students could take, particularly if their scores were not high. Since students could view the caramate units and take post-tests at their own individual pace, students of all abilities were able to at least double their averages for the post-tests, compared to pre-tests, Figure 4, page 7; this was expected, However, in the evaluation of the overall averages of post-tests, there was found no significant difference between population means among the three GPA groups, Figure 6! In my mind, the raising of the achievement of the lower GPA students to the level of higher GPA students, for post-tests, does illustrate two significant points:

1. In a program of audio-visual education where the senses are stimulated by vivid presentations—in this case, the Caramate slides—the levels of learning can be raised.

2. Given a factor of time where students can move at individual rates, lower GPA students can achieve at the same level of higher GPA students. At times, ability to achieve can be hampered by lack of sufficient time for learning to take place.

Finally, the student populations in biology, year after year, seem to show a constancy of academic achievement--that is, if the educational process maintains the same sets of standards and variables (3). The zoology midterm and final examination averages between the years 1972 and 1977 showed few significant differences in population means, in light of the constant method of presenting zoology in lectures, laboratory and field trip experiences (4). The 1977 Final examination sample means was higher, though, than than of previous years.

In summary, my teaching methods remained consistent along with standards; for example, students scoring in the 90 percentile in my classes have always received an A grade. In the spring of 1977, with a NSF-CAUSE program, I observed that most lower GPA students did achieve on a level with higher GPA students through a self-paced audio-tutorial slide program. There is much joy when I can observe a "C" student adequately compete with the high ability student and also achieve an "A" or "B" course grade. The audio-tutorial innovations will be further expanded in all my courses, and further evaluation and testing will help determine the validity of the results obtained for this report.

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(3) Robinson, David C. and Shrum, John W., "Assessment of a Competency Based Modular Biology Course," AIBA, March 1977, 228-231.

(4) Collins, Brian G., "Mastery Learning, Student Proctors, and Attitude Formation in an Audio-tutorial College Biology Program", AIBS Education Review, Vol. 5, No. 3: 10-15.

APPENDIX 1 PRE-COURSE QUESTIONNAIRE

See sample of questionnaire on the following page.

1. Courses

High school and college courses completed were weighted as BASIC or as OTHER than basic, in terms of scientific background. Points were assigned to each course in the various disciplines (see sample questionnaire).

2. Maximum Points

	TOTAL =	General Courses	Mathematics	Physical Sciences	Biological Sciences
High School					
BASIC	14 pts =	0	4 pts	6 pts	4 pts
OTHER	6 pts				
	20 pts				
College					
BASIC and ADVANCED	26 pts =	5 pts	5 pts	9 pts	7 pts
OTHER	4 or more				
	30 or more pts				
TOTAL POINTS	50 or more				
	3 pts maximum for "other experiences"				

3. Student's Code Number

General and mathematics courses were not considered for this 1977 Biology 2 evaluation. The student's total points for physical and biological science courses only were considered for the student's code number, to indicate the extent of the student's science background.

To compute the code number, student's total points were multiplied by the student's grade-point average for high school and college science courses only.

APPENDIX 1(continued) (points) = BASIC/ADVANCED

BIOLOGY PRE-COURSE QUESTIONNAIRE - 77 Chan

Your Name _____ (Last) (First)

Address _____ Zip _____ Phone _____

Age _____ Sex _____

I. HIGH SCHOOL graduation: Year _____ Name of School _____

Location: (City, State) _____

Check the high school courses you have completed:

14 = (4) Mathematics

- [1] Algebra
- [1] Geometry
- [2] Adv. Algebra
- Other 2 TRIG/ANAL GEOM
- 0 FOUNDATIONAL ALGEBRA 1

(6) Physical Sciences

- [3] Chemistry
- [3] Physics
- Other 1

(4) Biological Sciences

- [1] Biology
- [1] Physiology
- [2] Adv. Biology

II. COLLEGE or UNIVERSITY attended: _____ No. of Yrs _____

List degress, if any: _____ Major _____ Minor _____

Check the college courses you have completed:

26 = (5) General

- [2] English 1A
- [3] English 1B
- Other Eng.: 1
- [1] Geography
- Other 1

(5) Mathematics (ONLY IF NOT TAKEN IN HIGH SCHOOL)

- [1] Algebra
- [2] Adv. Alg.
- [1] Trigonometry
- [2] Calculus
- [2] Adv. Calculus
- Other 1

(9) Physical Sciences

- [3] Chemistry 1A
- [3] Chemistry 1B
- [3] Physics 2A
- [2] Geology
- Other 1
- 1

(9) Biological Sciences

- [3] Biology 1
- [2] Biology 2
- [2] Biology3
- Other 1
- 1
- 1

III. Estimated GRADE POINT AVERAGE:

High school: all courses _____, science courses _____

College/Univ:all courses _____, science courses _____

IV. Cite other experiences involving Biology-- in work, recreation, travel, clubs or organizations, magazines, etc.

APPENDIX 2

TO: SCIENCE FACULTY
FROM: GORDON CHAN
MAY, 1977
SUBJECT: COMPLETION OF SUPPLEMENTARY SLIDE CASSETTE UNITS FOR GENERAL ZOOLOGY

We have created 13 slide cassette units covering phyla from Protozoa to Mammals, which are intended to supplement the lecture and laboratory materials. The units include photos of organisms in their natural habitat, microphotography, taxonomy diagrams, and a descriptive narration. Please feel free to inquire with Ann Cole or me about how these units might be incorporated into your lesson plans. The following is a listing of the slides and species included in each carousel.

UNIT 1: PROTOZOA

Phylum: PROTOZOA
- *Subphylum: SARCODINA*
  - Amoeba proteus
  - Difflugia sp.
  - Foraminifera spp:
    - living
    - skeletons
    - Marginopora vertebrata
    - star-shaped foram
  - Heliosphaera sp.
  - Radiolarian shells
  - Actinosphaerium sp.
- *Subphylum: MASTIGOPHORA*
  - Euglena sp.
  - Chlamydomonas sp.
  - Volvox sp.
  - Ceratium sp.
  - Noctiluca scintillians
  - Trypanosoma sp.
  - Trichonympha sp.
  - Opalina sp.
- *Subphylum: SPOROZOA*
  - Gregarina sp.
  - Plasmodium vivax
- *Subphylum: CILOPHORA*
  - Paramecium spp:
    - conjugation
    - pellicle
    - fission
  - Vorticella sp.
  - Stentor sp.

UNIT 2: PORIFERA (sponges)

Phylum: PORIFERA
- Basic cellular organizations
- Illustration of body types
- *Class: CALCAREA*
  - Leucosolenia eleanor (marine)
  - Leucosolenia eleanor (microscope)
  - Rhabdodermella nuttingi
  - Rhabdodermella sp.(c.s.)
  - Grantia spp:
    - cross section (body folds)
    - c.s. (eggs in mesenchyme)
    - c.s. (amphiblastula larva)
  - Sponge spicules (w.m.)
  - Sponge gemmules
  - Sycon sp.
- *Class: HEXACTINELLIDA*
  - Euplectella sp.
  - Glass sponge
  - Glass vase sponge
- *Class: DEMOSPONGIAE*
  - Spongin spicules
  - Divers looking for sponges
  - Vase sponge
  - Sand in oscular cavity
  - Yellow sponge
  - Orange sponge
  - Brown sponge
  - Red encrusting sponge
  - Aplysilla glacialis
  - Sponge with predator
  - Tethya aurantia
  - Terpias zeteki
  - Polymastia pachymastia

UNIT 3: CNIDARIA
Part I: HYDROZOA, SCYPHOZOA

Phylum: CNIDARIA (Coelenterata)
Class: HYDROZOA
Hydra spp:
asexual budding
gastrovascular cavity
tentacles
cross section
female (ovaries)
male (testis)
Cnidoblast cells
Nematocysts
Agalophenia sp.
Tubularia sp.
Tubularia larynx
Tubularia carymorpha
Obelia spp:
gastrozooid
gonangium
hydromedusae
Millepora sp. Hydrocoral
Allopora californica:
underwater views
hybrids
close-up of dactylozooids
commensals
Gonionemus sp.
Polyorchis scrippsia
Physalia sp. Portuguese man-o-war
Physalia tentacle
Velella lata
Class: SCYPHOZOA
Aurelia spp: Bay jellyfish
Welts produced by nematocysts
planula larvae
scyphistoma
stroblia
ephyra
Pelagia panopyra jellyfish
Pelagia and diver

PART II: ANTHOZOA, CTENOPHORA

Class: ANTHOZOA
Sarcophytum sp.
Polyps of soft coral
Pink soft coral
Red soft coral
Gorgonia spp:
from Australia
from Sea of Cortez
close-up views of polyps
mixture of Gorgonians

Class: ANTHOZOA, cont.
Close-up of octocoral polyps
Leioptilus sp. sea pen
Renilla sp. sea pansie
Polyps of Renilla
Metridium sp. (c.s.) sea anemone
Anthopleura xanthogrammica
Aboral disc of sea anemone
Epiactis prolifera with young
Stoiactis sp. world's largest anemone
Metridium senile cotton top anemone
Telia sp. rose anemone
Corynactis californica ruby anemone
Pachycerianthus fimbriatus
burrowing anemone
Display of stony corals
Stony coral skeleton
Expanded coral polyp (living)
Acropora sp. coral plates
Colorful corals from Japan
Green coral (mutualistic algae)
Pollicipora sp.
Abstract coral
Wavy brain coral
Fungia sp. mushroom coral
Polyps of Fungia
Goniopora sp.
Tubastraea sp.
Balanophyllia elegans
Antipathes sp. black coral
Dr. Chan with black coral specimen

Phylum: CTENOPHORA
Ctenophores
Pleurobrachia bachei: sea gooseberries
on beach
close-up of tentacles, ctenes
Beroe sp.

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UNIT 4: LOWER WORMS
SECTION I: BASIC EMBRYOLOGICAL CONCEPTS OF METAZOANS

Illustration of symmetry types
Types of cleavage
Embryological development
Coelomic cavities
Eucoelomic cavities

SECTION II: ACOELOMATA WORMS

Phylum: PLATYHELMINTHES (flatworms)
Class: TURBELLARIA (free living)
Polychoerus carmelensis
Syndesmis franciscana
Dugesia planaria
Dugesia c.s.
Bipalium kewense
Stylochus sp.
Pseudoceros spp.
Class: TREMATODA (flukes)
Clonorchis siensis
Rediae fluke
Cercaria fluke
Fasciola hepatica
Schistosoma japonicum
Class: CESTOIDEA
Taenia sp:
Scolex
Immature proglottid
Mature proglottid
Gravid proglottid
Phylum: NEMERTINA (ribbon worms)
Tubulanus polymorpha
intertidal scenes
Brown and White Nemertians

SECTION III: PSEUDOCOELOMATE WORMS

Phylum: ASCHELMINTHES
Ascaris sp:
c.s. of male
c.s. of female
Necator americanus hookworm
Trichinella spiralis
Marine Rotifers
Gastrotrichs
Gordius sp. horsehair worm
Phylum: ENTOPROCTA
Barenstia gracilis
Phylum: PRIAPULIDA
Marine bristle worm
Phylum: ACANTHOCEPHLA
Spiny-headed pig worm

UNIT 5: LOPHOPHORATES and SCHIZOCOEL WORMS
SECTION I: LOPHOPHORATES

Phylum: PHORONIDA
Phoronopsis viridis:
micrograph
mud tubes in Tomales Bay
tubes exposes by tidal waves
tentacle lophophores exposed
Phylum: ECTOPROCTA
Pectinatella magnifica
Lophophore coelom
Bugula californica:
micrograph
avicularia
marine photo
Encrusting ectoproct
Membranipora sp.
Crisulipora occidentalis
Philodophora sp.
Phylum: BRACHIOPODA
Terebratalia transversa
Laqueus sp.
Lingula sp.

SECTION II: SCHIZOCOEL WORMS

Phylum: SIPUNCULIDA (peanut worms)
Dendrostomium sp.
Phylum: ECHIUROIDA (spoon worms)
Urechis caupo
Phylum: ANNELIDA (segmented roundworms)
Class: OLIGOCHAETA
Trochophore larvae
Lumbricus sp. earthworm, c.s.
Class: POLYCHAETA
Nereis sp:
Parapodium
Setae
Neanthis brandi:
Female, eggs in tide pool
Male, sperm in tide pool
Nepthys caecoides
Cirriformia luxuriosus
Fireworm
Spirobis sp.
Pragmatopoma californica
close-up of tubes
Eudistylia polymorpha tubed worm
Tentacles of tubed polychaete
Protula superba
Sabellid
Spirobranchus sp.
Phylum: ONCOPODA
Peripatus sp.

UNIT 6: ARTHROPODA

Phylum: ARTHROPODA
Subphylum: TRILOBITA
Trilobites seas
Trilobite fossil
Subphylum: CHELICERATA
Limulus polyphemus
Book gills of Limulus
Giant sea scorpion (extinct)
Sea spider
Pycnogonium stearnsis
Scorpions
Tarrantula
Dermacentor sp. (tick)
Subphylum: MANDIBULATA
Class CHILOPODA
Centipede
Class: DIPLOPODA
Milipede
Class: CRUSTACEA
Cephalocarida
Artemia sp. brine shrimp
Daphnia
Ostracod
Cyclops
Calcanus sp.
Fish louse
Lepas antifera
Barnacle nauplius larvae
Cypris larvae
Balanus nubilus
Squilla
Lydgia occidentalis
Sphaeroma sp.
Gammarus sp.
Orchestoidea californica
Caprella sp.
Pugettia producta
Grapsus crab
Cancer antennarias
Paniluris interruptus
Lobster catch
Spiny lobster larvae
Giant hermit crab
Eye stalks of hermit crab
Uca sp. fiddler crab
Pachygrapsus crassipes
Syra spp.
Blepharipoda occidentalis
Class : INSECTA
Insect trachea
Collembola sp. springtail
Praying mantis
Grasshopper mouth parts

Class: INSECTA cont.
Lepidoptera sp. moth caterpillar
White striped butterfly
Anopheles mosquito
Giant Brazillian ants
Apis melifica: honey bee
Wing hooks
Leg specialization

UNIT 7: MOLLUSCA

Phylum: MOLLUSCA
Class: AMPHINEURA (chitons)
Neopilina sp.
Tonicella lineata
Cryptochiton stelleri
Mopalia chiton (radula)
Class: SCAPHOPODA (tusk shells)
Tusk shell
Dentalium sp.
Class: PELECYPODA (bivalves)
Valve of clam
Scallops
Hinnites sp.
Mytilus californica
Mussel with Barnacles
Clams
Clam gill
Teredo sp.
Clam glochidia larvae
Oysters
Class: GASTROPODA (snails)
Trochophore larvae
Veliger larvae
Snail Radula
Abalone anatomy
Haliotus rufescens
Lottia gigantea
Radula marks of owl limpet
Collisella sp.
Megathura crenulata
Olivia porphyria
Cowries
Cyprea aurantium
Golden cowry
Cyprea spodicea
Tegula regina
Spindle conch
Kelletia sp.
Aletes sp.
Land snail

UNIT 7 cont.

Class: CEPHALOPODA (squid, octopi)
- Nautilus feeding
- Nautilus shell
- Fossil ammonites
- Architeuthis sp.
- Loligo opalescens:
  - local specimens
  - egg cases
  - radula
- Deep sea squid
- Sepia plangon
- Giant Octopus
- 2 day old octopus
- Eye of octopus

UNIT 8: ECHINODERMATA

Phylum: ECHINODERMATA
- Dipleurula larvae
- Echinoderm development
- Pluteus larvae
- Seastar spiny skin
- Internal skeleton
- Water-vascular system

Class: CRINOIDEA (sea lilies)
- Fossil crinoid
- Pacific crinoid
- Cenolia sp.

Class: OPHUIROIDEA (brittle stars)
- Ophiopterus papillosa
- Serpent star
- Gorgonocephalus sp.
- Ophiothrix spiculata
- Ophiothrix nocternal scene

Class: ASTEROIDEA (seastars)
- Pisaster giganteus
- Sieve plate (madreporite)
- Pedicellariae
- Pisaster ochraceous
- Pisaster, aggregating
- Henricia leviscula blood seastar
- Patiria miniata Bat star
- Patiria cluster
- Seastar coloration
- Nidorella armata yellow bat star
- Oreaster occidentalis
- Linckia sp.
- Pycnopodia sp. sunstar
- Acanthaster planci crown of thorns:
  - damage to reefs
  - close up of spines
  - Triton (predator)

Class: ECHINOIDEA (urchins, sand dollars)
- Dendraster sp. sand dollar
- Encope grandis key hole sand dollar
- Heart urchin
- Diadema sp. tropical urchin
- Echinothrix sp. poisonous urchin
- Strongylocentrotus franciscana
- Strongylocentrotus purpuratus
- Sea urchin teeth
- Pycnopodia helianthodes (predator)
- Sea urchin gonads
- Lytechinus sp.
- Toxopneustes piliolus

Class: HOLOTHUROIDEA (sea cucumbers)
- Psolus chitonoides
- Stichopus sp.
- Stichopus parvimensis
- Cucamaria sp:
  - sequence of rupturing intestines (defensive)
- Euapta sp.
- Thelonata sp.
- Bohadschia sp.
- Cucumaria miniata
- Uncommon speices
- Leptosynapta albicans

UNIT 9: PRE- and EARLY CHORDATES

Phylum: CHAETOGNATHA
- Sagitta sp.

Phylum: POGONOPHORA
- Beard worms

Phylum: HEMICHORDATA
- Balanoglossus sp.
- Cross section of hemichordate
- Saccoglossus sp.

Phylum: CHORDATA

Subphylum: UROCHORDATA
- Tunicate haul
- Ascidia ceratodes
  - whole
  - dissceted
- Tunicate tadpole larvae
- Clavelina huntsmani
- Colonial tunicates
- Masking crab covered with tunicates
- Cahined salp
- Salpa maxima
- Large salp
- Giant salp

UNIT 9 cont.

Subphylum: CEPHALOCHORDATA
- Amphioxus sp.
- Amphioxus, c.s.

Subphylum: VERTEBRATA

Class: AGNATHA
- Ostracoderm
- Hagfish
- Lamprey:
  - whole organism
  - Ammocete larvae
  - Cross section
- Dinichthys sp.

Class: CHONDRICHTHYES (cartilaginous fish)
- Chlamydosalechus sp.
- Frill shark head
- Placoid scale of shark
- Shark embryo, c.s.
- Cetorhinus maximus
- Basking shark:
  - washed up on beach
  - head and mouth
  - gill slits, gill bars
  - Eye, olfactory organs
  - observers
- Carcharodon sp.
- Jaw of white shark
- White shark attacking diver
- Boy killed by white shark
- Sphyrna zygaena
- Alopias vulpinus
- Embryo dogfish shark
- Swell shark grasping own tail
- Nurse shark egg case
- Guitar fish
- Mylobatis californicus
- Hydrolagus collei ratfish

UNIT 10: OSTEICHTHYES

Phylum: CHORDATA

Subphylum: VERTEBRATA

Class: CONDRICHTHYES
- Chimera sp. link organism (ratfish)

Class: OSTEICHTHYES (bony fish)

Subclass: ACTINOPTERYGII (ray-finned)
- Fin ray
- Ganoid scale
- Sturgeon
- Paddlefish
- Polypterus
- Garpike
- Large garpike, Mississippi
- Bowfin

Subclass: ACTINPOTERYGII cont.

Superorder: TELEOSTI
- Pacific Herring
- Cycloid scale
- Pacific Sardine
- Northern Anchovy
- Steelhead Rainbow Trout
- Pacific Saury
- Deep sea fish
  - modified spines of
- Piranha
- California Flying Fish
- Tarpon, Barracuda
- Blennies
- Moray Eel
- Atlantic Seahorse
- Bay Pipefish
- Striped Bass
- Ctenoid scale
- Dorsal spines of Perch

Order: PERCIFORMES
- Striped Sea Perch
- Lingcod, mouth
- Young Gariboldi
- Adult Gariboldi
- Sheephead, female
- Blue Damsel Fish
- White striped Angel Fish
- Yellow tail Sturgeon
- Black-nose Butterfly Fish
- Lion Fish
- Broadbill Swordfish
- Giant Bluefin
- Sculpin
- Rock Sculpin
- Midshipman
- Starry Flounder
  - both sides
- Pacific Halibut
- Triggerfish
- Porcupine Fish
- Mola-mola

Subclass: SARCOPTERYGII (lobe-finned)
- African Lungfish
- Coelacanth:
  - living
  - preserved
  - lobe-fin, close-up

UNIT 11: AMPHIBIA, REPTILIA, AVES

Phylum: CHORDATA
Subphylum: VERTEBRATA
Class: AMPHIBIA
- Ancient Crossopterygians
- Coelacanth
- Early Amphibian
- Cecilian
- Salamander
- Vomerine teeth
- Frog
- Salamander skull
- Frog tadpoles

Class: REPTILIA
- Seymouria
- Lycaenops
- Ichthyosaurus (fossils)
  - Head
  - Vertebrae
- Elasmosaurus
- Pleisaur display
- Brontosaurus
- Tyrantosaurus rex
- Dinosaur eggs
- Rattlesnake jaw
- Snake skeleton
- Horned Lizard
- Sea Turtle
- Saddleneck Turtle
- Marine Iguana

Class: AVES
- Archeopteryx
- Blue Peacock
- Bird Feather vanes
- Bird mandibles
- Bird Feet
- Breast Bone
- Egg of Elephant Bird
- Osprey
- Penguin
- Kildeer
- Hummingbird
- Finch
- Brown Pelican

UNIT 12: MAMMALIA

Phylum: CHORDATA
Subphylum: VERTEBRATA
Class: MAMMALIA
- Elephant Seal pup (General characteristics)

Subclass: PROTHERIA (egg-laying)
- Spiny Anteater
- Platypus

Subclass: THERIA (viviparous)
- Kangaroo
- Dog (scent glands)
- Camel
- Rhinocerous
- Walrus
- Baleen of Grey Whale
- Camel (teeth)
- Saber-tooth Tiger
- Mastadon
- Elk
- Human Embryo
- Tarsier
- Whale
- Manatee
- Killer Whale
- Bat
- African Early Man
- Baby with tail (human)
- Gorilla
- Orangutan, female

UNIT 13: REVIEW

A review unit, highlighting major points covered in each of the preceeding units.

APPENDIX 3

Summary of Student Evaluation of Slide-Caramate Units for Biology 2, Spring 1977

		Very Useful	Somewhat Useful	Not Useful
1.	Usefulness of the Slide Units for:			
	a. Zoology	16	12	0
	b. Biology terminology	13	11	4
	c. Taxonomy	15	12	0
	d. Study of Natural Habitats	15	12	1
	e. Supportive of lecture/lab	13	14	1
	f. Making up lab work	12	10	2
	g. Working ahead, self-advancement	12	13	0
2.	Usefulness of the Post-tests for:			
	a. Comprehension of the subjects	23	5	0
	b. Relating lecture/lab	14	12	1
	c. Preparing for midterm exams	19	8	1

		Yes	Somewhat Confusing	No	no response
	d. Clarity of questions in the post-tests	10	18	0	
	e. Would take post-tests if they were optional	23		1	4
3.	Would view the units if they were optional	25		1	1
4.	Felt benefited from the units	25		0	3
5.	Would recommend continuing the use of units	25		0	3

		Often	Sometimes	Never	no response
6.	Concerning the operation/mechanics of the units:				
	a. Interferred with the learning process	0	12	13	3
	b. Availability of the units at the Media Lab	24	1		3
	c. Photographs were clear	24	1		3
	d. Tapes were audible	6	17	2	3

APPENDIX 4

COMPARISON of STATISTICAL DATA for MIDTERM 1 and FINAL EXAMINATIONS

FOR BIOLOGY 2 CLASSES, 1972-1977

Year	← Midterm 1 Exam → Total Points Midterm 1 Exam	Students	Midterm 1 Average	Standard Deviation	95% confidence interval for population mean	← Final Exam → Total Points Final Examination	Students	Final Exam Average	Standard Deviation	95% confidence interval for population mean	Year
1972	70	43	46.3	12.3	42.6-49.9	150	40	101.0	15.0	96.3-105.6	1972
1973	59	40	44.8	9.6	41.8-47.7	150	40	114.5	14.6	109.9-119.0	1973
1974	60	39	41.2	10.0	38.1-44.4	150	38	116.8	17.8	111.2-122.4	1974
1975	60	50	47.1	8.2	44.9-49.4	150	47	118.3	17.0	113.4-123.1	1975
1976	60	55	49.2	8.1	47.1-51.4	150	49	119.9	16.4	115.3-124.5	1976
1977	60	34	48.4	7.9	45.8-51.1	150	30	123.4	11.9	119.2-127.7	1977

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